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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/687,183	10/16/2003	Jung-Chih Tsao	TS03-120	7588
8933	7590	05/04/2005	EXAMINER	
DUANE MORRIS, LLP			ESTRADA, MICHELLE	
IP DEPARTMENT			ART UNIT	
ONE LIBERTY PLACE			PAPER NUMBER	
PHILADELPHIA, PA 19103-7396			2823	

DATE MAILED: 05/04/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/687,183

Applicant(s)

TSAO ET AL.

Examiner

Michelle Estrada

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 16 February 2005.
2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-52 is/are pending in the application.
4a) Of the above claim(s) 1-33 is/are withdrawn from consideration.
5) ☐ Claim(s) _____ is/are allowed.
6) ☒ Claim(s) 34-52 is/are rejected.
7) ☐ Claim(s) _____ is/are objected to.
8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date 1/15/04

- 4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____

DETAILED ACTION

Election/Restrictions

Applicant's election with traverse of Group II (claims 34-52) in the reply filed on 2/16/05 is acknowledged. The traversal is on the ground(s) that the examination of all claims 1-52 would not impose an undue burden on the Examiner because the method claims 1-33 produce the semiconductor device claimed in the device claims 34-52. This is not found persuasive because the Examiner gave enough reason of why the product as claimed can be made by another and materially different process.

The requirement is still deemed proper and is therefore made FINAL.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 34-52 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lin (6,093,656) in view of Sugai (6,569,756).

Re claims 34 and 45, Jang discloses a first copper layer (16) having vertical sidewalls, a planar bottom, and a concave top surface formed in an opening in a dielectric layer (6) on a substrate (7), said first copper layer has a first thickness; and a second copper layer (18) having vertical sidewalls, a substantially planar top surface

that is about coplanar with the top of said dielectric layer, and a convex bottom surface that forms an interface with said concave top surface of said first copper layer, said second copper layer has a second thickness and is formed in said opening in a dielectric layer on a substrate (See fig.1).

Jang does not disclose that the first copper layer has a grain density G_{D1} and that the second copper layer has a grain density G_{D2} .

Sugai discloses forming a first copper layer (5) having vertical sidewalls, and a planar bottom formed in an opening in a dielectric layer (2) on a substrate (1), said first copper layer has a first thickness; and a second copper layer (6) having vertical sidewalls, a substantially planar top surface that is about coplanar with the top of said dielectric layer, said second copper layer has a second thickness and is formed in said opening in a dielectric layer on a substrate; each copper layer is made by different method and conditions, therefore the first copper layer has a grain density G_{D1} and the second copper layer has a grain density G_{D2} .

It would have been within the scope of one of ordinary skill in the art to combine the teachings of Jang and Sugai to enable the copper density step of Jang to be performed according to the teachings of Sugai because one of ordinary skill in the art would have been motivated to look to alternative suitable methods of performing the disclosed copper formation step of Jang and art recognized suitability for an intended purpose has been recognized to be motivation to combine. See MPEP 2144.07. Furthermore, making the first copper layer by CVD almost no bumps and dips occur, and forming the second copper layer by sputtering will permit copper wiring to be

formed in a short time, thus making the process suitable for volume production (Col.4, lines 55-58 and Col. 5, lines 55-57).

Re claims 35 and 46, Sugai discloses wherein said substrate is further comprised of an upper etch stop layer (11) and the opening (13) extends through said etch stop.

Re claim 36, Jang discloses wherein said dielectric layer is comprised of SiO₂ (Col. 2, lines 32-33).

Re claims 38 and 48, Sugai discloses further comprised of a conformal diffusion barrier layer (4) formed in said opening along the sidewalls and bottom of said first copper layer and along the sidewalls of said second copper layer (See fig. 1B).

Re claim 40, Sugai discloses wherein said copper interconnect has a sheet resistance that is nearly independent of the width of said first copper layer and the width of said second copper layer.

Re claims 41, 49 and 50, Sugai discloses wherein said opening is part of a pattern that includes a plurality of other openings having a pattern density and said copper interconnect has a sheet resistance (Rs) that is nearly independent of said pattern density.

Re claims 42 and 51, Jang discloses wherein the first thickness of said first copper layer is equal to or greater than the second thickness of said second copper layer (See fig. 1).

Re claim 44, Sugai discloses wherein the substrate could be layer (11) and is comprised of a metal layer and said first copper layer of said copper interconnect is formed above said metal layer and forms an electrical contact to said metal layer.

One of ordinary skill in the art would have been led to the recited copper thickness and width, and density through routine experimentation to achieve a desired device dimension, device associated characteristics and device density on the finished wafer. Note that density is an optimizable variable since it depends on optimizable variables like quantity and volume.

In addition, the selection of copper thickness and width, and density, is obvious because it is a matter of determining optimum process conditions by routine experimentation with a limited number of species of result effective variables. These claims are prima facie obvious without showing that the claimed ranges achieve unexpected results relative to the prior art range. In *re* Woodruff, 16 USPQ2d 1935, 1937 (Fed. Cir. 1990). See also In *re* Huang, 40 USPQ2d 1685, 1688 (Fed. Cir. 1996) (claimed ranges of a result effective variable, which do not overlap the prior art ranges, are unpatentable unless they produce a new and unexpected result which is different in kind and not merely in degree from the results of the prior art). See also In *re* Boesch, 205 USPQ 215 (CCPA) (discovery of optimum value of result effective variable in known process is ordinarily within skill of art) and In *re* Aller, 105 USPQ 233 (CCPA 1995) (selection of optimum ranges within prior art general conditions is obvious).

Note that the specification contains no disclosure of either the critical nature of the claimed copper thickness and width, and density or any unexpected results arising therefrom. Where patentability is said to be based upon particular chosen copper thickness and width, and density or upon another variable recited in a claim, the

Applicant must show that the chosen copper thickness and width, and density are critical. *In re Woodruf*, 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936 (Fed. Cir. 1990).

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Michelle Estrada whose telephone number is 571-272-1858. The examiner can normally be reached on Monday through Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached on 571-272-1855. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 571-272-2800.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should

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you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

A handwritten signature in black ink, appearing to read "Michelle Estrada". The signature is fluid and cursive, with a large initial "M" and "E".

Michelle Estrada
Examiner
Art Unit 2823

ME
May 2, 2005